VBA Internals and Technology

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Topics

- Design Goals
- Implementation
- VBA and OLE2
- VBA Overview and Architecture
- VBA Compiler
- VBA Engine

Design Goals

- VB language compatibility
- Efficiency: compile-time and run-time
- Application hostability
- High Productivity
- Development Environment
- Portability
- Localizable
- Standard
- Cross-application Programmability

Implementation

- C++ for OO features and portability
- Assembler as appropriate: engine parts
  - VBA and VB3 performance comparable.
- Modular Engine
- Complete redesign/“Written from scratch”
- Scalable technology
  - Seamless OLE2 interaction

OLE Automation

- Ole Automation (OA) is a set of standard interfaces supporting programmable objects.
- IDispatch: supports run-time binding and run-time invocation.
  - IDispatch::GetIDsOfNames: run-time binding
  - IDispatch::Invoke: run-time invocation
  - needed for untyped variables: Object/Variant
- ITypeLib: provides compile-time descriptions of set of programmable objects
  - ITypeLib contains set of ITypeInfos
  - ITypeInfo describes object: methods, properties, variables.
  - Supports compile-time binding

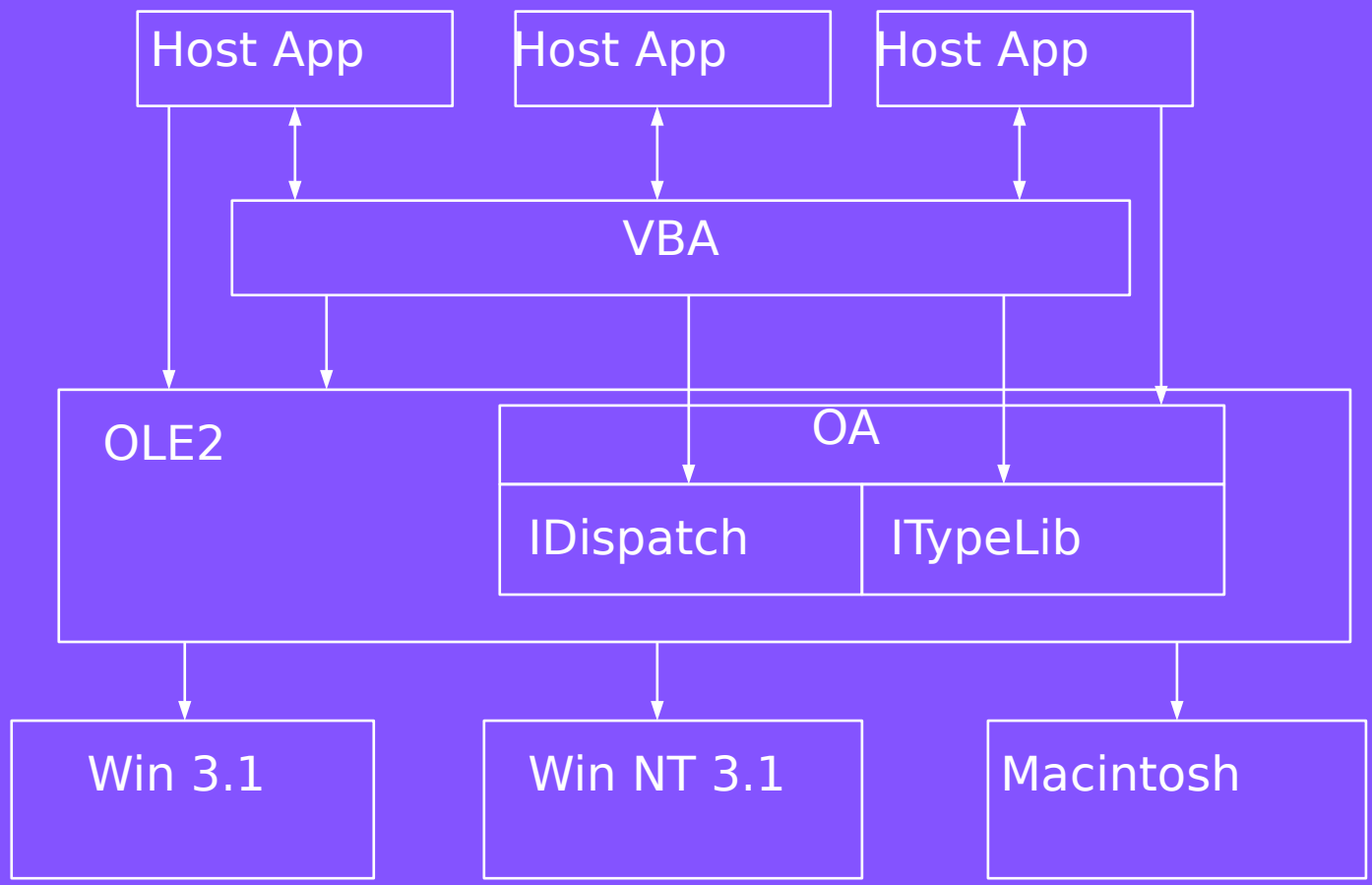
VBA and OLE2

- VBA uses Ole Automation
  - uses ITypeLib/ITypeInfo as well unlike VB3.
- VBA can control any application that exposes programmable objects via IDispatch
- VBA is more efficient if application provides a type library as well for its programmable objects
  - Also provides compile-time type checking
  - And object browsing
- VBA uses OA String, Variant, Array package to implement run-time
  - Exceptions: numerical conversions

VBA and OLE2

- VBA uses OLE2 to implement cross-process object invocation (function call/property access)
  - Extensible to cross-machine/net calls!
- VBA uses OLE2 standard interfaces for memory management and file storage
  - Host-customizable: VBA program can be stored anywhere, e.g. in a spreadsheet.
- Big Market for OA components
  - Language independent
  - THE Microsoft programmability solution

Programmability Architecture



VBA and Host Integration

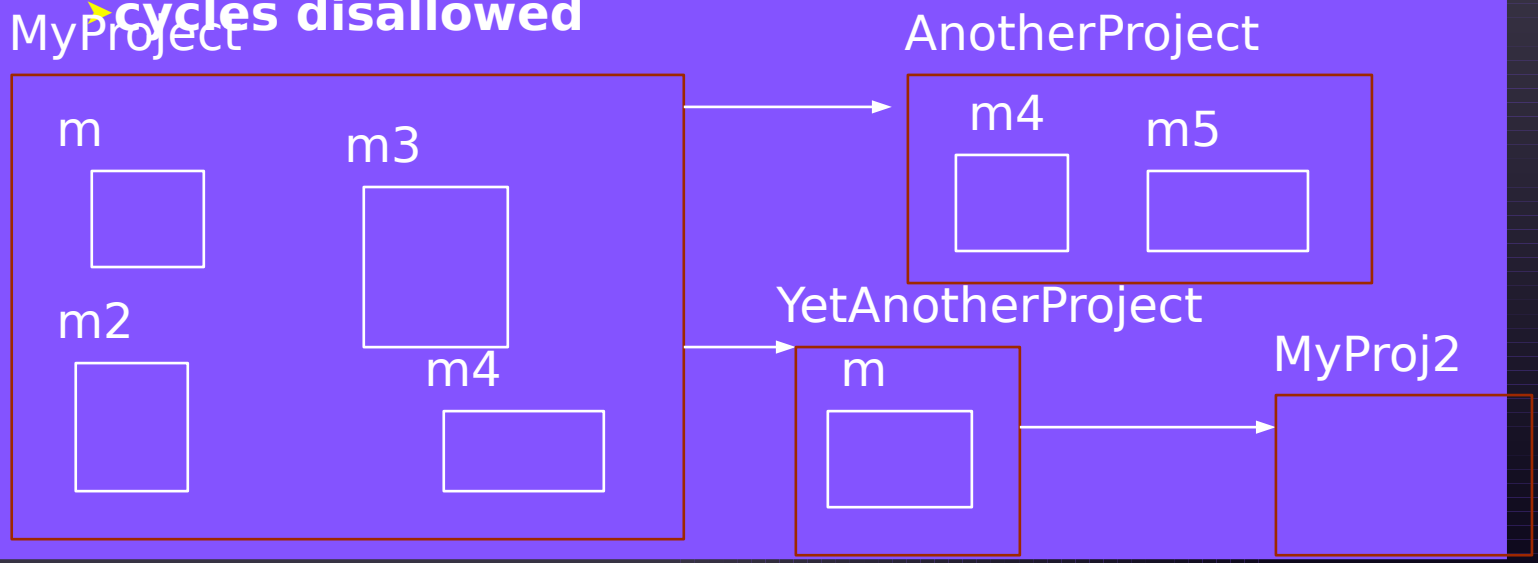
- VBA works and appears identically in all host applications.
- VBA interacts with host-supplied objects in similar ways across multiple applications.
  - Since host applications implement similar Object Models (by convention)

VBA Components

- **Incremental Compiler**
  - syntax and semantic analysis
  - code generation
  - inter-module dependency analysis
- **User Interface**
  - code editor
  - object browser
  - debugger
  - immediate window
  - watch expressions
- **Engine**
- **Run-time**
  - implemented as a library

Project Model

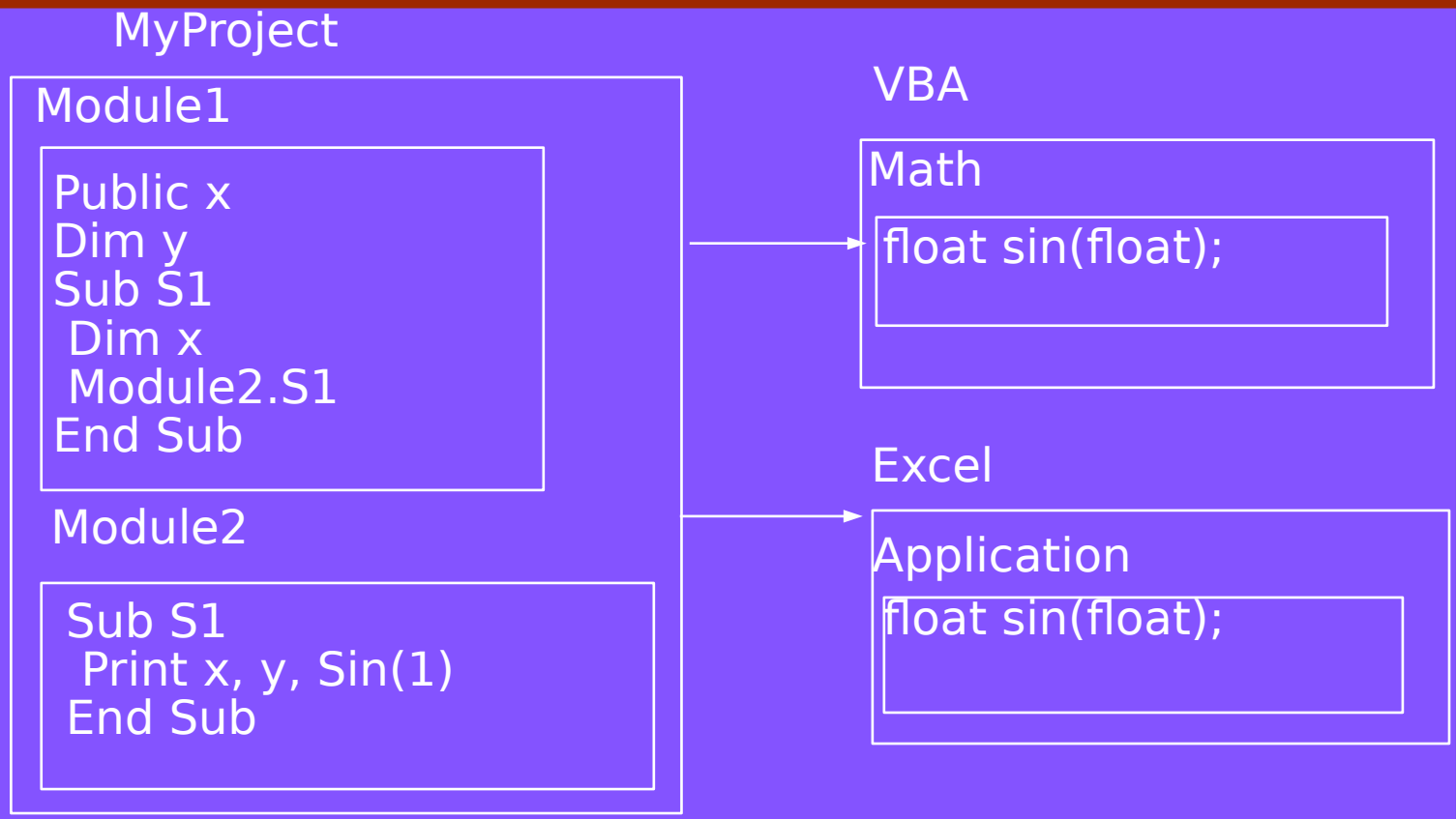
- Project is a collection of Modules
  - Project is an implementation of ITypeLib
- Module is an implementation of ITypeInfo
- Project has list of referenced Projects
  - cycles disallowed



Name Scoping

- Structured
  - Procedure-level
  - Module-level: public and private
- Explicit qualification
  - Call MyProj2.M2.S2
- Referenced projects
  - Names in directly referenced projects available without qualification.
  - Names in indirectly referenced projects available require qualification
- Private modules
- Application objects
  - Set myWorksheet = Worksheets.Add

Namespace Example



- **Beware of Implicit Variables**
- **Look, no Declares!**

Binding

- “The Earlier the Better”
- Three kinds of binding
  - Early (static) binding
    - VBA to VBA binding
    - VBA to DLL binding
  - Early (late id) binding
    - VBA to ITypeLib object method/property
  - Late (name) binding
    - VBA to OA object method/property
- Run-time binding with OA GetIDsOfNames/Invoke

Binding Example

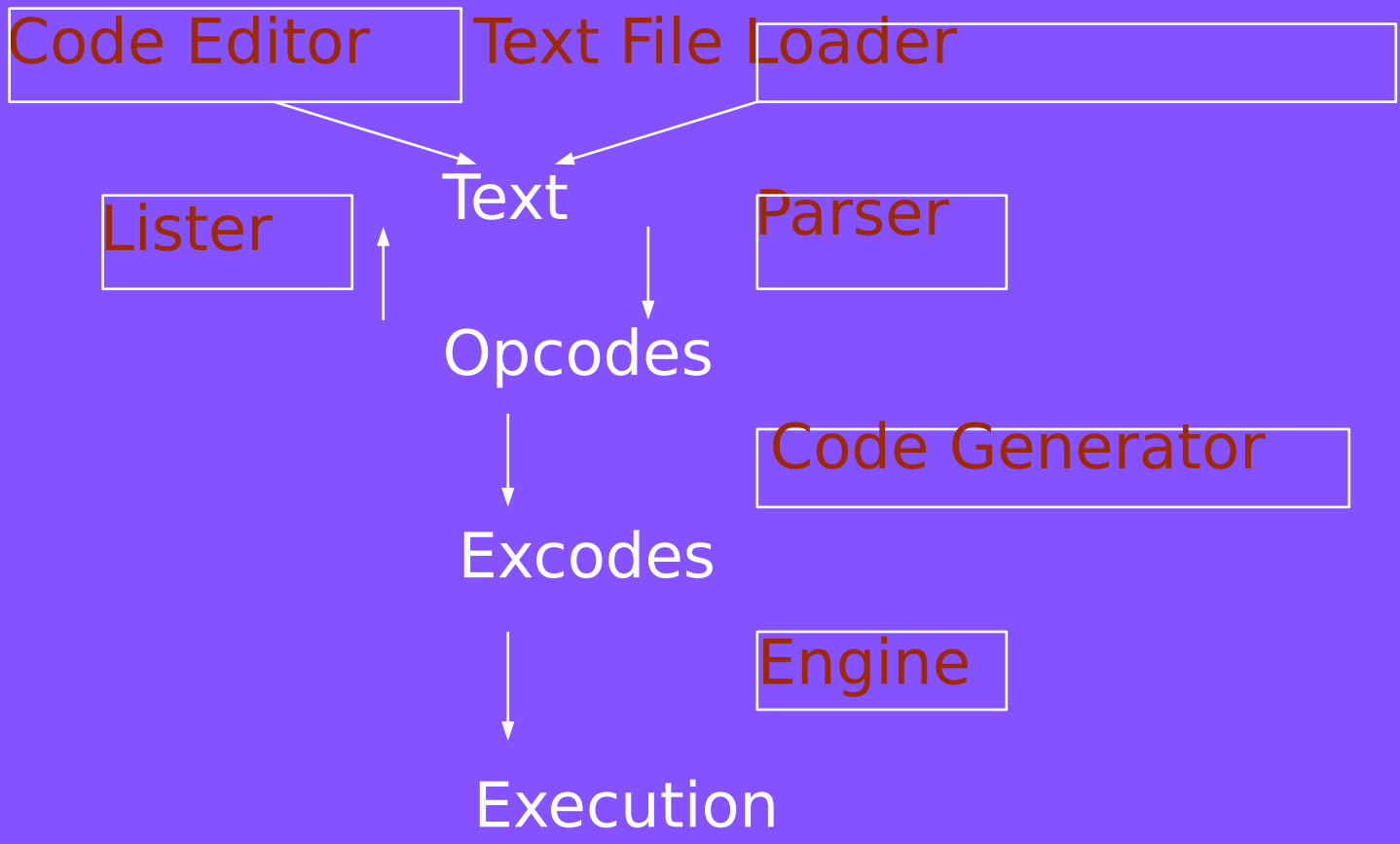
```
Dim w2 as Worksheet
Dim c as Object
Dim w as Object
Sub S2()
 S1
End Sub
Sub S1
 Set w = Workbooks.Add
 Application.Visible = true
 Set w2 = Worksheets(“sheet1”)
 Set c = ActiveCell
 c = w2.Name
 Cells(1, 2).Activate
 Set c2 = ActiveCell
 c2.Value= w.Name
End Sub
```

Early Static
Early (late id)
Late (name)

Compiler Overview

- Dual p-code representation
  - opcodes: produced by parser
  - excodes: produced by code-generator
- Opcodes: postfix representation of source
  - retains sufficient information to recreate original source text
- Excodes: small and optimized
  - all references are bound
  - unnecessary “decoration” is discarded: e.g. comments
  - code generator performs both semantic analysis and codegen
- Both opcodes and/or excodes can be saved and reloaded.

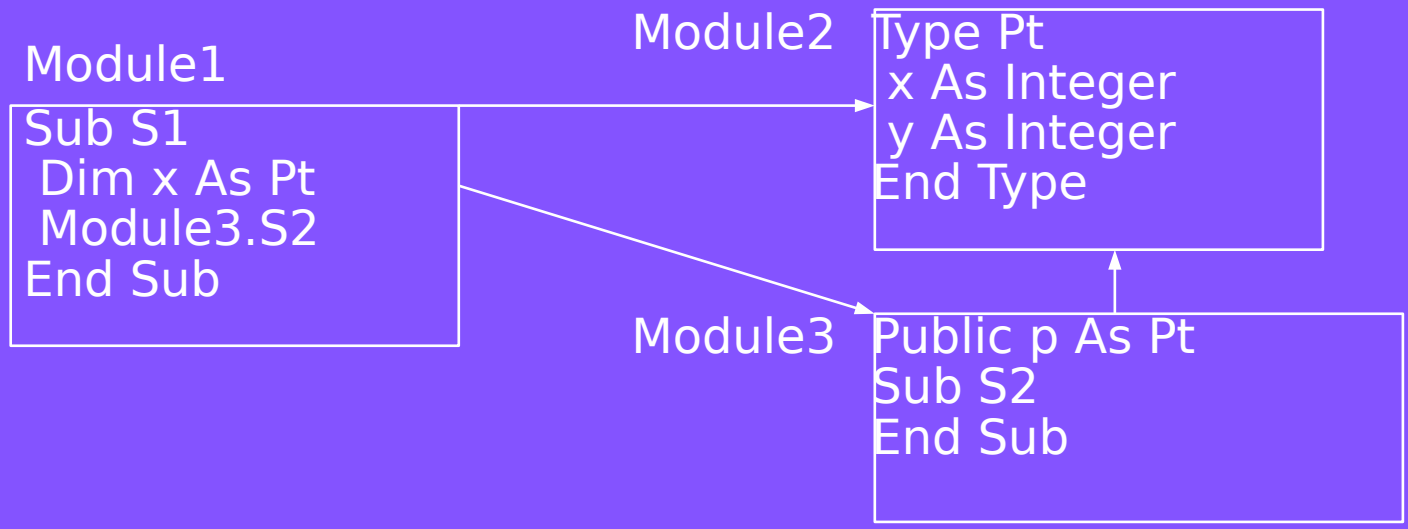
Compiler Flow



Compilation States

- VBA implements “just-in-time” (demand) compilation and decompilation.
  - Optimized for high productivity/rapid development turnaround
- Fundamental compilation unit is module.
- Multiple-states:
  - undeclared (parsed)
  - declared (laid out: shape known)
  - compiled (generated code)
  - runnable (functions can be called)
- Inter-module dependency tracking mechanism determines when and which modules are compiled and decompiled.

Dependency Example



- Edits to Module1 never affect state of the other modules.
- Calling Module3.S2 only requires Module2 and Module3 to be compiled
  - Module1 need not be compiled.
- However, calling Module1 requires all three to be compiled.

Engine

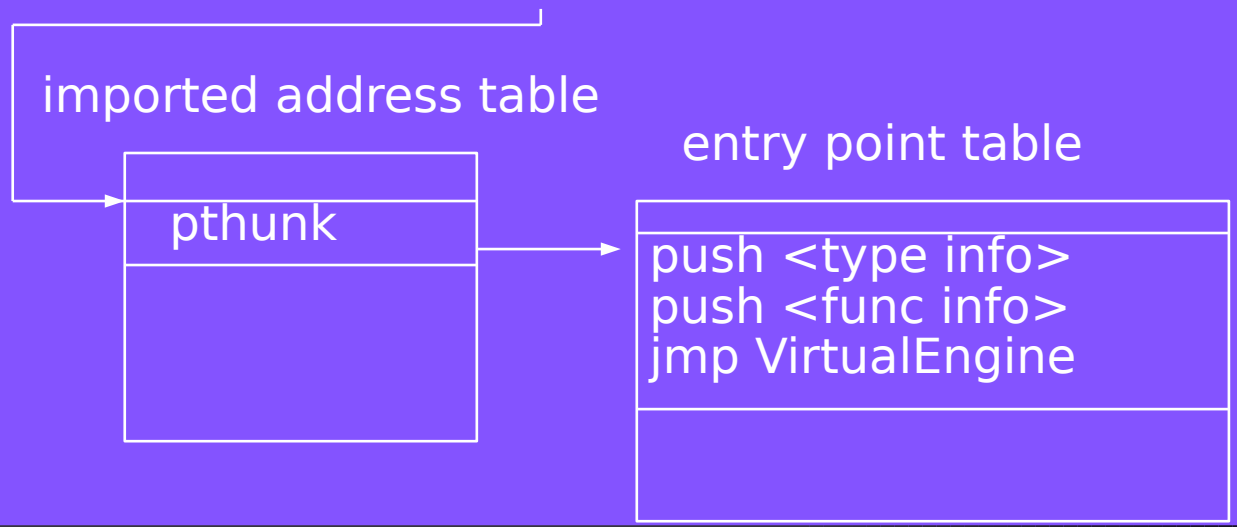
- Code generator produces code for virtual machine
  - Virtual Machine language is excodes
  - Excodes are postfix representation of program
- Stack machine
  - Single register
  - Frame pointer
  - Stack pointer
- Engine executes excodes
- Single segment (for efficiency)

VBA to VBA Function Call

```
Sub S1()
 Call S2
End Sub

REM Perhaps in another module or even project
Sub S2()
End Sub
```

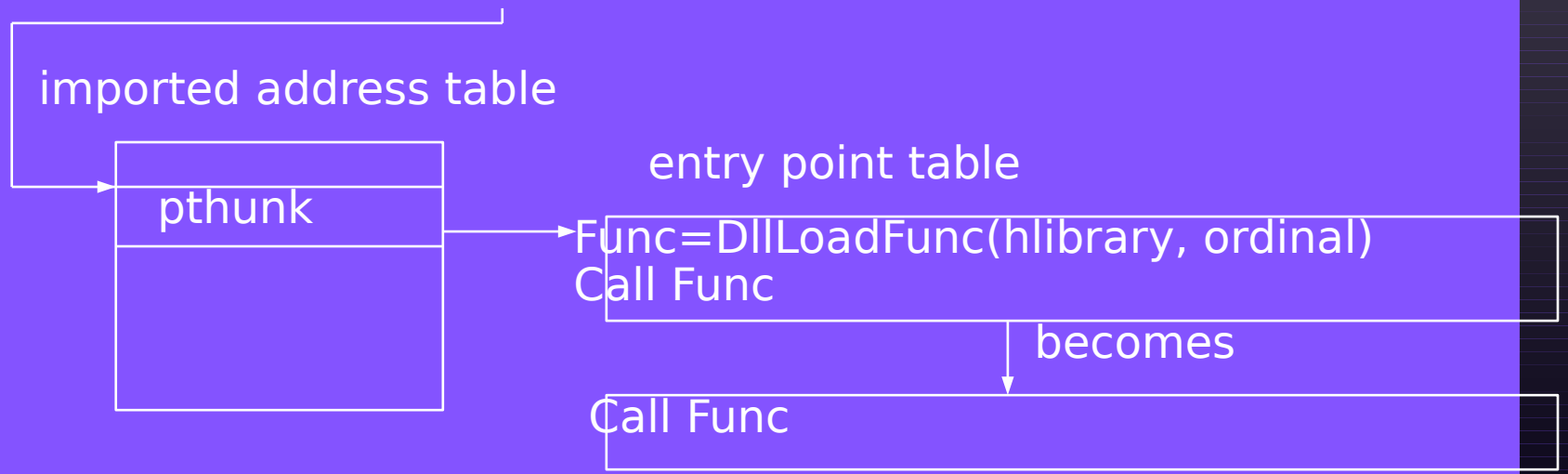
```
 EX_Call <func handle> // excode for simple Call
```



VBA to DLL Function Call

```
Declare Sub S2 Lib “MyLib” ()
Sub S1()
 Call S2
End Sub
```

- **Same excode as VBA to VBA case**
- **Thunk modified at run-time**



Cross-process activation

- Example of VBA macro executed in Excel5
  - in-process
- Excel5 objects packaged in type library
- Example of same macro executed by sample host application manipulating Excel5
  - cross-process
    - OA provides communications layer
  - Server application activated implicitly. No need for explicit CreateObject

Questions?